

449122021000

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

10/049865
Not yet assigned

INTERNATIONAL APPLICATION NO PCT/DE00/02691	INTERNATIONAL FILING DATE August 10, 2000	PRIORITY DATE CLAIMED August 16, 1999
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TITLE OF INVENTION

CIRCUIT AND METHOD FOR DETERMINING AN OFFSET ERROR OF A MEASUREMENT SUBJECT TO AN OFFSET ERROR OF A COIL CURRENT OF AN ELECTROMAGNETIC ACTUATOR (AS AMENDED)

APPLICANT(S) FOR DO/EO/US

Thomas FRANZ et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. is attached hereto (required only if not communicated by the International Bureau)
 - b. has been communicated by the International Bureau.
 - c. is not required, as the application was filed in the United States Receiving Office (RO/US)
6. An English language translation of the International Application under PCT Article 19 (35 U.S.C. 371(c)(2)).
 - a. is attached hereto
 - b. has been previously submitted under 35 U.S.C. 154(d)(4).
7. Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. are attached hereto (required only if not communicated by the International Bureau)
 - b. have been communicated by the International Bureau.
 - c. have not been made, however, the time limit for making such amendments has NOT expired.
 - d. have not been made and will not be made.
8. An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3))
9. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5))

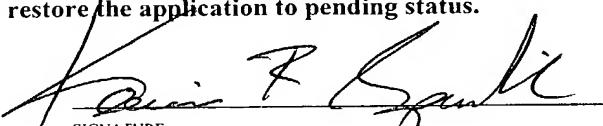
Items 11. to 16. below concern document(s) or information included:

11. An Information Disclosure Statement under 37 CFR 1.97 and 1.98
12. An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. A **FIRST** preliminary amendment.
14. A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. A substitute specification
16. A change of power of attorney and/or address letter.
17. A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825
18. A second copy of the published international application under 35 U.S.C. 154(d)(4)
19. A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. Other items or information 1) Application Data Sheet; 2) Int'l Search Report; 3) IPER; 4) Return receipt postcard.

CERTIFICATE OF HAND DELIVERY

I hereby certify that this correspondence is being hand filed with the United States Patent and Trademark Office in Washington, D.C. on February 19, 2002.


Melissa Carton

U.S. APPLICATION NO (if known, see 37 CFR 1.5) Not yet assigned	INTERNATIONAL APPLICATION NO PCT/DE00/02691	ATTORNEY DOCKET NO 449122021000			
<p>21. <input checked="" type="checkbox"/> The following fees are submitted:</p> <p>BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)):</p> <p>Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.....\$1,000.00</p> <p>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO\$890.00</p> <p>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO.....\$710.00</p> <p>International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provision of PCT Article 33(1)-(4)\$690.00</p> <p>International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)\$100.00</p>		CALCULATIONS PTO USE ONLY			
ENTER APPROPRIATE BASIC FEE AMOUNT =		\$890.00			
<p>Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).</p>		\$0			
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	- 20 =		x \$18.00	\$0	
Independent claims	- 3 =		x \$80.00	\$0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00	\$0	
		TOTAL OF ABOVE CALCULATIONS =	\$890.00		
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½.			\$0		
		SUBTOTAL =	\$890.00		
<p>Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).</p>		+ \$0			
		TOTAL NATIONAL FEE =	\$890.00		
<p>Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property</p>		+ \$40.00			
		TOTAL FEES ENCLOSED =	\$930.00		
		Amount to be refunded:	\$		
		charged:	\$		
a. <input checked="" type="checkbox"/> Please charge my <u>Deposit Account No. 03-1952</u> (referencing Docket No. 449122021000) in the amount of \$930.00 to cover the above fees. A duplicate copy of this sheet is enclosed.					
b. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees that may be required, or credit any overpayment to <u>Deposit Account No. 03-1952</u> (referencing Docket No. 449122021000).					
<p>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.</p>					
<p>SEND ALL CORRESPONDENCE TO:</p> <p>Kevin R. Spivak Morrison & Foerster LLP 2000 Pennsylvania Avenue, N.W. Washington, D.C. 20006-1888</p>					
 <p>SIGNATURE</p> <p>Kevin R. Spivak Registration No. 43,148</p>					
<p>February 19, 2002</p>					

JC11 Rec'd PCT/PTO 19 FEB 2002

CERTIFICATE OF HAND DELIVERY

I hereby certify that this correspondence is being hand filed with the United States Patent and Trademark Office in Washington, D.C. on February 19, 2002



Melissa Garton

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the application of:

Thomas FRANZ et al.

Serial No.: Not yet assigned

Filing Date: February 19, 2002

For: CIRCUIT AND METHOD FOR
DETERMINING AN OFFSET
ERROR OF A MEASUREMENT
SUBJECT TO AN OFFSET ERROR
OF A COIL CURRENT OF AN
ELECTROMAGNETIC
ACTUATOR (AS AMENDED)

Examiner: Not yet assigned

Group Art Unit: Not yet assigned

PRELIMINARY AMENDMENT**BOX PCT**

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination on the merits, please amend this application as follows:

In the Specification:

Page 1, before the first paragraph, please delete the following:

Description

Page 1, before the first paragraph, please change the Title as follows:

**CIRCUIT AND METHOD FOR DETERMINING AN OFFSET ERROR OF A
MEASUREMENT SUBJECT TO AN OFFSET ERROR OF A COIL CURRENT OF AN
ELECTROMAGNETIC ACTUATOR**

Page 1, between lines 6 and 7, please insert the following headings and paragraph:

CLAIM FOR PRIORITY

This application claims priority to International Application No. PCT/DE00/02691 which was published in the German language on August 10, 2000.

TECHNICAL FIELD OF THE INVENTION

Please replace the paragraph beginning line 7 of page 1 with the following rewritten paragraph:

The invention relates to a circuit and a method for determining the offset error of a measurement, and in particular, determining the offset error of a measurement that is subject to an offset error of a coil current of an electromagnetic actuator.

Page 1, between lines 11 and 12, please insert the following heading:

BACKGROUND OF THE INVENTION

Please replace the consecutive paragraphs beginning at line 12 of page 1 with the following rewritten paragraphs:

Electromagnetic actuators, which for example drive a gas exchange valve of an internal combustion engine, usually have at least one coil. An electromagnetic actuator for gas exchange valves is known, for example, from DE 297 12 502 U1 or EP 0 724 067 A1. It has a rest position, which lies between a closed position and an open position and from which it can be deflected by means of electromagnets.

To open or close a gas exchange valve driven by the actuator, the coil assigned to the respective final position is supplied with current, the required current being greater in the capture phase than in the holding phase, in which the gas exchange valve is held in the final position of the actuator.

If the corresponding electromagnet is provided with current, the valve disk of the gas exchange valve hits the valve seat at high speed, which produces noise and is conducive to wear.

To avoid this, the striking speed must be reduced. For this purpose, the current supply is suitably controlled.

For this purpose, the coil current of the electromagnetic actuators is measured. This can take place, for example, by potential taps at a resistor connected in series with the coil.

According to Ohm's law, the current can be calculated from the value of the resistance and the measured voltage drop.

The voltage drop is usually sensed with an analog circuit. In such an analog circuit, an offset error is unavoidable, i.e. the measured voltage is too great or too small. A measuring device which performs an automatic offset voltage compensation is known from DE 34 29 854 A1, but a special hybrid module is required for it, which is relatively expensive. A similarly acting circuit arrangement is known from DE 34 48 182 C2. In this case, a memory module is used for the offset compensation.

Page 2, between lines 14 and 15, please insert the following headings and paragraphs:

SUMMARY OF THE INVENTION

In one embodiment of the invention, there is a method for determining the offset error of a measurement, where the measurement is subject to such an offset error of a coil current of an electromagnetic actuator, comprising measuring the coil current through a corresponding coil when the actuator is in a final position in which the coil is not supplied with current during the operation of the actuator, and providing the value obtained as the offset error.

In another aspect of the invention, the coil current is measured by potential tapping before and after a resistor connected in series with the coil, wherein the potential taps are being fed to a differential amplifier, and a constant value is added to a value output by the differential amplifier.

In another aspect of the invention, the actuator has two coils respectively assigned to the final position, and the coil current through the coil not assigned to the present final position is measured to determine the offset error.

In yet another aspect of the invention, the method includes supplying the coil assigned to the final position with a capture current and a holding current such that the actuator is transferred into the final position.

In another embodiment of the invention, there is a circuit for determining the offset error of a measurement, the measurement subject to an offset error of a coil current I of an electromagnetic actuator, the circuit comprising at least one coil with a resistor connected in series into a supply line of the coil, a differential amplifier to which the potential on both sides of the resistor is fed, and a control circuit which evaluates the output of the differential amplifier when the coil is not carrying any current during the operation of the actuator, and the value obtained is output as the offset error I_o .

In another aspect of the invention, wherein the output of the differential amplifier is fed together with the output of a constant-voltage source to an adding element such that an offset error of a specific polarity is obtained.

In another aspect of the invention, the actuator has first and second coils assigned to a final position, and a resistor is connected in the supply line to each coil, the differential amplifier taps the voltage dropping across the resistor, and the control circuit evaluates outputs of the differential amplifiers.

In still another aspect of the invention, the control circuit for supplying current to the first and second coils transfers the actuator into a final position, and the first coil assigned to the final position carries a capture current and a holding current, and the control circuit evaluates the output of the differential amplifier of the second coil.

In another aspect of the invention, the offset error I_o is determined and low-pass-filtered multiple times.

BRIEF DESCRIPTION OF THE DRAWINGS

An exemplary embodiment of the invention is explained in more detail below with reference to the drawings, in which:

Figure 1 shows a section through an actuator for a gas exchange valve of an internal combustion engine.

Figure 2 shows the time series of the current flow through the two coils of Figure 1.

Figure 3 shows a circuit for sensing the coil current through a coil.

Figure 4 shows the states passed through during the operation of the gas exchange valve in a flow diagram.

~~CONFIDENTIAL~~

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Please replace the paragraph beginning line 15 of page 2 with the following rewritten paragraph:

The invention relates to a circuit of an electromagnetic actuator and a method for determining the offset error of a measurement that is subject to such an offset error of the coil current of an electromagnetic actuator, with the result that no special modules are required.

Please delete the paragraph beginning at line 22 of page 2 in its entirety.

Please replace the consecutive paragraphs beginning at line 25 of page 2 with the following rewritten paragraphs:

In the invention, there is a final position of the actuator in which a coil is not supplied with current. If the coil current is measured at this point in time, the offset error can be determined.

In the case of an actuator which is used, for example, for driving a gas exchange valve and for opening or closing the gas exchange valve, the coil assigned to the corresponding final position is firstly supplied with a capture current. Then, a holding current is supplied, and the determination of the offset error is preferably performed on that coil which is assigned to the other final position when the coil supplied with current is in the holding phase. This is because, at this point in time, the coil of the circuit for which the offset error is being determined is not supplied with current. In the capture phase, on the other hand, the coil is still briefly supplied with current during the capture phase for the delayed transfer of the actuator into the other final position. Since, for example, the current from its previous holding phase can still decay.

Please delete the paragraph beginning at line 12 of page 3 in its entirety.

Please delete the paragraph beginning at line 15 of page 3 and ending at line 31 of page 3 in its entirety.

Please replace the paragraph beginning line 33 of page 3 with the following rewritten paragraph:

Figure 1 shows an electromagnetic actuator 1 for a gas exchange valve. The actuator 1 is shaped, for example, as which is designed as a disk valve and comprises a valve disk 2 with a valve seat 3 and a valve stem 4, which is mounted in a guide 5 on the housing side and is provided at the upper end with a conical piece 6. The valve disk is moved by the actuator 1 between two final positions: in an upper final position, the gas exchange valve is closed and in a lower final position it is open.

Please replace the paragraph beginning line 11 of page 5 with the following rewritten paragraph:

In Figure 2, the current I through the coil 14 or 16 is plotted over time t. In this case, the current I through the coil 14 is represented by a solid line, the current through the coil 16 is represented by a dashed line. This current flow is set by the control circuit 28, in order with the aid of a capture current circuit to switch the valve over into the other final position, respectively, reliably and without bouncing. For this purpose, the holding current H_s, H_o holding the armature 18 in the respective final position is switched off, so that the armature is set in motion in the direction of the other final position by the relevant, relaxing spring. At the same time, the corresponding winding 14 or 18 is supplied with the capture current F_o, F_s. For closing the valve, the coil 14 is supplied with the capture current F_s. If the armature 18 is resting on the end face 19, the coil 14 is then supplied with lower holding current H_s, which is sufficient to hold the armature 18, and consequently the gas exchange valve, in the closed position.

Please replace the consecutive paragraphs beginning at line 7 of page 6 with the following rewritten paragraphs:

The gas exchange valve passes through the states I to IV represented in Figure 4. In state I, the valve is closed and the holding current H_s is flowing in the coil 14. Next, in state II, the valve is opened, for which purpose the coil 16 is supplied with the capture current F_o, and the holding current H_s in the coil 14 slowly decays. Once the armature 18 has come up against the end face 20, the supply of current to the coil 16 is switched over to the holding current H_o and the valve is open (state III of figure 4). For closing, the coil 14 is in turn provided with capture current, which is represented in figure 4 as state IV. Once the armature 18 has come up against the end face 19, state I exists again.

In order then to be able to use the current through the coil 14, 16 in the control circuit 28, a measurement of the coil current is necessary. A driver circuit used for this purpose is represented, together with a more accurate representation of the control circuit 28, by way of example in Figure 3. Figure 3 shows the driver circuit 26 for the coil 14. The driver circuit 27 is designed in an analogous way.

As shown in Figure 3, the coil 14 is activated by an asymmetric half-bridge. In this case, the coil 14 is connected between a highside FET Th, which on the other hand is connected to the supply voltage Vcc, and a lowside FET Tl, which in turn is connected via a resistor R to the reference potential. Connected in the forward direction between the reference potential and the connecting nodes of the coil 14 to the highside FET Th is a diode D2. Connected in the forward direction between the connecting nodes of the coil 14 to the lowside FET Tl and the supply voltage Vcc is a diode D1. Finally, the supply voltage Vcc is connected to the reference potential via a capacitor C. Between the lowside FET Tl and the reference potential there lies a resistor R.

Please replace the consecutive paragraphs beginning at line 21 of page 7 with the following rewritten paragraphs:

If the desired current is zero, the highside and lowside FETs Th, Tl are turned off. In this state, no current flows through the resistor R and the voltage at the input of the differential amplifier 30 is zero. On account of the internal construction of the differential amplifier 30, it is possible however for a negative voltage to be present at the output as the result of an offset error.

In the case of a measuring chain of a unipolar construction, as usually used in automotive electrical engineering, however, a negative measuring voltage is undesired. For this reason, an artificially generated offset is added on at the adding node 31. For this purpose, the output of a constant-voltage source 32 is additionally fed to the adding node 31. Consequently, there is a positive voltage present at the input of the filter 33.

For determining the offset error, the resistor R must not be flowed through by a current. This is accomplished for the coil 14 in the holding phase of the other coil 16, since this is the final position in which the coil 14 for the circuit 26 of which the offset error is to be determined is not supplied with current. After determination of the offset error I_o of the non-activated coil,

the actual current I_m can be corrected as follows when the coil is next activated in the then-following cycle: $I_{corr} = I_m - I_o$

Please replace the consecutive paragraphs beginning at line 19 of page 8 with the following rewritten paragraphs:

This weighted average value is one possible form of low-pass filter; others are conceivable as readily understood by the skilled artisan. In this case, $I_{o,i}$ is the ith measurement of the offset error, I_m is the actual value of the current(raw value of the analog/digital converter 34) and k is a weighting factor.

The low-pass filtering takes account of the realization that the offset error I_o fluctuates in a temperature-dependent manner and changes slowly with respect to the sampling rate with which the offset error is determined.

In the Claims:

What is claimed is:

1. (Amended) A method for determining the offset error of a measurement, where the measurement is subject to such an offset error of a coil current of an electromagnetic actuator, comprising:

measuring the coil current through a corresponding coil when the actuator is in a final position in which the coil is not supplied with current during the operation of the actuator; and

providing the value obtained as the offset error.

2. (Amended) The method as claimed in claim 1, wherein the coil current is measured by potential tapping before and after a resistor connected in series with the coil, wherein

the potential taps are being fed to a differential amplifier, and a constant value is added to a value output by the differential amplifier.

3. (Amended) The method as claimed in claim 1, wherein the actuator has two coils respectively assigned to the final position, and

the coil current through the coil not assigned to the present final position is measured to determine the offset error.

3 13 23 43 53 63 73 83 93 103 113 123 133

4. (Amended) The method as claimed in claim 3, further comprising:
supplying the coil assigned to the final position with a capture current and a holding current such that the actuator is transferred into the final position.

5. (Amended) A circuit for determining the offset error of a measurement, the measurement subject to an offset error of a coil current I of an electromagnetic actuator, the circuit comprising:
at least one coil with a resistor connected in series into a supply line of the coil;
a differential amplifier to which the potential on both sides of the resistor is fed; and
a control circuit which evaluates the output of the differential amplifier when the coil is not carrying any current during the operation of the actuator, and the value obtained is output as the offset error I_o .

6. (Amended) The circuit as claimed in claim 5, wherein the output of the differential amplifier is fed together with the output of a constant-voltage source to an adding element such that an offset error of a specific polarity is obtained.

7. (Amended) The circuit as claimed in claim 5, wherein the actuator has first and second coils assigned to a final position, and
a resistor is connected in the supply line to each coil, the differential amplifier taps the voltage dropping across the resistor, and the control circuit evaluates outputs of the differential amplifiers.

8. (Amended) The circuit as claimed in claim 7, wherein the control circuit for supplying current to the first and second coils transfers the actuator into a final position, and
the first coil assigned to the final position carries a capture current and a holding current, and the control circuit evaluates the output of the differential amplifier of the second coil.

9. (Amended) The method as claimed in claim 1, wherein the offset error I_o is determined and low-pass-filtered multiple times.

In the Abstract:

Please replace the Abstract with the substitute Abstract attached hereto.

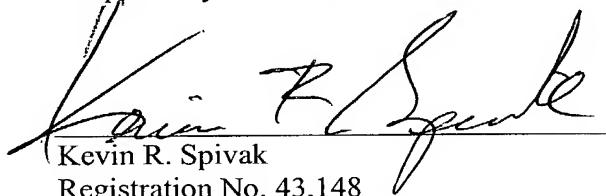
REMARKS

The above amendments to the specification, claims, and abstract have been made to place the application in proper U.S. format and to conform with proper grammatical and idiomatic English. None of the amendments herein are made for reasons related to patentability. No new matter has been added.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "**Version with markings to show changes made**".

In the unlikely event that the transmittal letter is separated from this document and the Patent Office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing docket no. 449122021000. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Respectfully submitted,



Kevin R. Spivak
Registration No. 43,148

Dated: February 19, 2002

Morrison & Foerster LLP
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Washington, D.C. 20006-1888
Telephone: (202) 887-6924
Facsimile: (202) 263-8396

VERSION WITH MARKINGS TO SHOW CHANGES MADE

For the convenience of the Examiner, the changes made are shown below with deleted text in strikethrough and added text in underline.

In the Specification:

Page 1, before the first paragraph, please delete the following:

Description

Page 1, before the first paragraph, please change the Title as follows:

**CIRCUIT AND METHOD FOR DETERMINING THE AN OFFSET ERROR OF A
MEASUREMENT ~~THAT IS SUBJECT TO SUCH~~ SUBJECT TO AN OFFSET ERROR
OF THE A COIL CURRENT OF AN ELECTROMAGNETIC ACTUATOR**

Page 1, between lines 6 and 7, please insert the following headings and paragraph:

CLAIM FOR PRIORITY

This application claims priority to International Application No. PCT/DE00/02691 which was published in the German language on August 10, 2000.

TECHNICAL FIELD OF THE INVENTION

Please replace the paragraph beginning line 7 of page 1 with the following rewritten paragraph:

The invention relates to a circuit and a method for determining the offset error of a measurement, and in particular, determining the offset error of a measurement that is subject to such an offset error of the a coil current of an electromagnetic actuator.

Page 1, between lines 11 and 12, please insert the following heading:

BACKGROUND OF THE INVENTION

Please replace the consecutive paragraphs beginning at line 12 of page 1 with the following rewritten paragraphs:

Electromagnetic actuators, which for example drive a gas exchange valve of an internal combustion engine, usually have at least one coil. An electromagnetic actuator for gas exchange valves is known, for example, from DE 297 12 502 U1 or EP 0 724 067 A1. It has a rest position, which lies between a closed position and an open position and from which it can be deflected by means of electromagnets.

To open or close a gas exchange valve driven by this the actuator, the coil assigned to the respective final position is supplied with current, the required current being greater in the capture phase than in the holding phase, in which the gas exchange valve is held in the final position of the actuator.

If the corresponding electromagnet is in this case simply provided with current, the valve disk of the gas exchange valve hits the valve seat at high speed, which produces noise and is conducive to wear. To avoid this, the striking speed must be reduced. For this purpose, the current supply is suitably controlled.

For this purpose, it is necessary in the case of electromagnetic actuators to measure the coil current of the electromagnetic actuators is measured. This can take place, for example, by potential taps at a resistor connected in series with the coil. By means of According to Ohm's law, the current can be calculated from the value of the resistance and the measured voltage drop.

The voltage drop is usually sensed with an analog circuit. In the case of such an analog circuit, an offset error is unavoidable, i.e. the measured voltage is too great or too small. A measuring device which performs an automatic offset voltage compensation is known from DE 34 29 854 A1, but a special hybrid module is required for it, which is relatively expensive. A similarly acting circuit arrangement is known from DE 34 48 182 C2. In this case, a memory module is used for the offset compensation.

Page 2, between lines 14 and 15, please insert the following headings and paragraphs:

SUMMARY OF THE INVENTION

In one embodiment of the invention, there is a method for determining the offset error of a measurement, where the measurement is subject to such an offset error of a coil current of an electromagnetic actuator, comprising measuring the coil current through a corresponding coil

when the actuator is in a final position in which the coil is not supplied with current during the operation of the actuator, and providing the value obtained as the offset error.

In another aspect of the invention, the coil current is measured by potential tapping before and after a resistor connected in series with the coil, wherein the potential taps are being fed to a differential amplifier, and a constant value is added to a value output by the differential amplifier.

In another aspect of the invention, the actuator has two coils respectively assigned to the final position, and the coil current through the coil not assigned to the present final position is measured to determine the offset error.

In yet another aspect of the invention, the method includes supplying the coil assigned to the final position with a capture current and a holding current such that the actuator is transferred into the final position.

In another embodiment of the invention, there is a circuit for determining the offset error of a measurement, the measurement subject to an offset error of a coil current I of an electromagnetic actuator, the circuit comprising at least one coil with a resistor connected in series into a supply line of the coil, a differential amplifier to which the potential on both sides of the resistor is fed, and a control circuit which evaluates the output of the differential amplifier when the coil is not carrying any current during the operation of the actuator, and the value obtained is output as the offset error I_0 .

In another aspect of the invention, wherein the output of the differential amplifier is fed together with the output of a constant-voltage source to an adding element such that an offset error of a specific polarity is obtained.

In another aspect of the invention, the actuator has first and second coils assigned to a final position, and a resistor is connected in the supply line to each coil, the differential amplifier taps the voltage dropping across the resistor, and the control circuit evaluates outputs of the differential amplifiers.

In still another aspect of the invention, the control circuit for supplying current to the first and second coils transfers the actuator into a final position, and the first coil assigned to the final position carries a capture current and a holding current, and the control circuit evaluates the output of the differential amplifier of the second coil.

In another aspect of the invention, the offset error I_0 is determined and low-pass-filtered multiple times.

BRIEF DESCRIPTION OF THE DRAWINGS

An exemplary embodiment of the invention is explained in more detail below with reference to the drawings, in which:

Figure 1 shows a section through an actuator for a gas exchange valve of an internal combustion engine.

Figure 2 shows the time series of the current flow through the two coils of Figure 1.

Figure 3 shows a circuit for sensing the coil current through a coil.

Figure 4 shows the states passed through during the operation of the gas exchange valve in a flow diagram.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Please replace the paragraph beginning line 15 of page 2 with the following rewritten paragraph:

The invention is based on the object of providing a relates to a circuit of an electromagnetic actuator and a method for determining the offset error of a measurement that is subject to such an offset error of the coil current of an electromagnetic actuator, with the result that no special modules are required.

Please delete the paragraph beginning at line 22 of page 2 in its entirety.

Please replace the consecutive paragraphs beginning at line 25 of page 2 with the following rewritten paragraphs:

The invention is based on the realization that In the invention, there is a final position of the actuator in which a coil is not supplied with current. If the coil current is measured at this point in time, the offset error can be determined from this.

In the case of an actuator which is used, for example, for driving a gas exchange valve and in the ease of which, for opening or closing the gas exchange valve, the coil assigned to the corresponding final position is firstly supplied with a capture current and then with. Then, a

holding current is supplied, and the determination of the offset error is preferably performed on that coil which is assigned to the other final position when the coil supplied with current is in the holding phase. This is because, at this point in time, it is ensured that the coil of the circuit for which the offset error is being determined is not supplied with current. In the capture phase, on the other hand, this is not ensured, since for example the current from its previous holding phase can still decay or, under certain circumstances, the coil is still briefly supplied with current during the capture phase for the delayed transfer of the actuator into the other final position. Since, for example, the current from its previous holding phase can still decay.

Please delete the paragraph beginning at line 12 of page 3 in its entirety.

Please delete the paragraph beginning at line 15 of page 3 and ending at line 31 of page 3 in its entirety.

Please replace the paragraph beginning line 33 of page 3 with the following rewritten paragraph:

Figure 1 shows an electromagnetic actuator 1 for a gas exchange valve ~~which is designed as~~. The actuator 1 is shaped, for example, as which is designed as a disk valve and comprises a valve disk 2 with a valve seat 3 and a valve stem 4, which is mounted in a guide 5 on the housing side and is provided at the upper end with a conical piece 6. The valve disk is moved by the actuator 1 between two final positions: in an upper final position, the gas exchange valve is closed and in a lower final position it is open.

Please replace the paragraph beginning line 11 of page 5 with the following rewritten paragraph:

In ~~f~~Figure 2, the current I through the coil 14 or 16 is plotted over time t. In this case, the current I through the coil 14 is represented by a solid line, the current through the coil 16 is represented by a dashed line. This current flow is set by the control circuit 28, in order with the aid of a capture current circuit to switch the valve over into the other final position, respectively, reliably and without bouncing. For this purpose, the holding current Hs, Ho holding the armature 18 in the respective final position is switched off, so that the armature is set in motion in the direction of the other final position by the relevant, relaxing spring. At the same time, the corresponding winding 14 or 18 is supplied with the capture current Fo, Fs. For closing the valve, the coil 14 is supplied with the capture current Fs. If the armature 18 is resting on the end

face 19, the coil 14 is then ~~only~~ supplied with lower holding current H_s , which is sufficient to hold the armature 18, and consequently the gas exchange valve, in the closed position.

Please replace the consecutive paragraphs beginning at line 7 of page 6 with the following rewritten paragraphs:

~~In other words,~~ The gas exchange valve passes through the states I to IV represented in ~~Figure~~ 4. In state I, the valve is closed and the holding current H_s is flowing in the coil 14. Next, in state II, the valve is opened, for which purpose the coil 16 is supplied with the capture current F_o , and the holding current H_s in the coil 14 slowly decays. Once the armature 18 has come up against the end face 20, the supply of current to the coil 16 is switched over to the holding current H_o and the valve is open (state III of figure 4). For closing, the coil 14 is in turn provided with capture current, which is represented in figure 4 as state IV. Once the armature 18 has come up against the end face 19, state I exists again.

In order then to be able to use the current through the coil 14, 16 in the control circuit 28, a measurement of the coil current is necessary. ~~The~~ A driver circuit ~~required~~ used for this purpose is represented, together with a more accurate representation of the control circuit 28, by way of example in ~~Figure~~ 3. Figure 3 shows the driver circuit 26 for the coil 14. The driver circuit 27 is designed in an analogous way.

~~As can be seen~~ shown in ~~Figure~~ 3, the coil 14 is activated by an asymmetric half-bridge. In this case, the coil 14 is connected between a highside FET T_h , which on the other hand is connected to the supply voltage V_{cc} , and a lowside FET T_l , which in turn is connected ~~on the other hand~~ via a resistor R to the reference potential. Connected in the forward direction between the reference potential and the connecting nodes of the coil 14 to the highside FET T_h is a diode D_2 . Connected in the forward direction between the connecting nodes of the coil 14 to the lowside FET T_l and the supply voltage V_{cc} is a diode D_1 . Finally, the supply voltage V_{cc} is connected to the reference potential via a capacitor C . Between the lowside FET T_l and the reference potential there lies a resistor R .

Please replace the consecutive paragraphs beginning at line 21 of page 7 with the following rewritten paragraphs:

If the desired current is zero, the highside and lowside FETs Th, Tl are turned off. In this state, no current flows through the resistor R and the voltage at the input of the differential amplifier 30 is zero. On account of the internal construction of the differential amplifier 30, it is possible however for a negative voltage to be present at the output as the result of an offset error. In the case of a measuring chain of a unipolar construction, as usually used in automotive electrical engineering, however, a negative measuring voltage is undesired. For this reason, an artificially generated offset is added on at the adding node 31. For this purpose, the output of a constant-voltage source 32 is additionally fed to the adding node 31. Consequently, there is a positive voltage present at the input of the filter 33.

For determining the offset error, ~~it must be ensured that the resistor R is must not be~~ flowed through by a current. This ~~can only be ensured is~~ is accomplished for the coil 14 in the holding phase of the other coil 16, since this is the ~~eoneems~~ a final position in which the coil 14 for the circuit 26 of which the offset error is to be determined is not supplied with current. After determination of the offset error I_o of the non-activated coil, the actual current I_m can be corrected as follows when the coil is next activated in the then-following cycle: $I_{corr} = I_m - I_o$

Please replace the consecutive paragraphs beginning at line 19 of page 8 with the following rewritten paragraphs:

This weighted average value is one possible form of low-pass filter; others are conceivable as readily understood by the skilled artisan. In this case, $I_{o,i}$ is the ith measurement of the offset error, I_m is the actual value of the current(raw value of the analog/digital converter 34) and k is a weighting factor.

This-The low-pass filtering takes account of the realization that the offset error I_o fluctuates in a temperature-dependent manner and changes only slowly with respect to the sampling rate with which the offset error is determined.

In the Claims:

Patent claims

What is claimed is:

1. (Amended) A method for determining the offset error of a measurement ~~that, where~~
~~the measurement~~ is subject to such an offset error of ~~the a~~ coil current of an electromagnetic
actuator(1), in which method
, comprising:

~~the measurement that is subject to the offset error of measuring~~ the coil current through a
coil(14, 16) ~~is performed corresponding coil~~ when the actuator (1) is in a final position in which
the coil (14, 16) is not supplied with current during the operation of the actuator(1); and
providing the value obtained is taken as the offset error.

2. (Amended) The method as claimed in claim 1, characterized in that ~~wherein~~ the coil
current is measured by potential tapping before and after a resistor connected in series with the
coil(14, 16); wherein

~~the potential taps are being fed to a differential amplifier(30), and a constant value being~~
~~is added to the a value output value of by the differential amplifier(30) in order always to obtain~~
~~an offset error signal of a specific polarity.~~

3. (Amended) The method as claimed in ~~one of the preceding claims, characterized in~~ that, in the case of an actuator (1) with two coils (14, 16) claim 1, wherein the actuator has two
coils respectively assigned to a the final position, and

~~the coil current through that the coil (14, 16) which is not assigned to the present final~~
~~position is measured for determining to determine~~ the offset error.

4. (Amended) The method as claimed in claim 3, characterized in that, for transferring
the actuator (1) into a final position, the coil (14, 16) assigned to this final position is firstly
supplied further comprising:

~~supplying the coil assigned to the final position with a capture current and then, after~~
~~reaching the final position, with a holding current, and in that then the determination of the offset~~
~~error is carried out on the other coil (14, 16). a holding current such that the actuator is~~
~~transferred into the final position.~~

5. (Amended) A circuit for determining the offset error of a measurement ~~that is, the measurement~~ subject to such an offset error of the ~~a~~ coil current I of an electromagnetic actuator(1) ~~having, the circuit comprising:~~

at least one coil (14, 16), with a resistor (R) connected in series into a supply line of the coil(14, 16);

a differential amplifier (30), to which the potential on both sides of the resistor (R) is fed; and

a control circuit (33, 34, 35), which evaluates the output of the differential amplifier (30) when the coil (14, 16) is not carrying any current during the operation of the actuator(1), and takes the value obtained is output as the offset error I_o .

6. (Amended) The circuit as claimed in claim 5, characterized in that wherein the output of the differential amplifier (30) is fed together with the output of a constant-voltage source (32) to an adding element (31), with the result that there is always such that an offset error signal of a specific polarity is obtained.

7. (Amended) The circuit as claimed in ~~one of the preceding circuit claims~~, characterized in that, for an actuator with two coils, respectively claim 5, wherein the actuator has first and second coils assigned to a final position(19, 20), and

a resistor (R) is connected in the supply line to each coil(14, 16), a the differential amplifier (30) ~~respectively~~ taps the voltage dropping across ~~said~~ the resistor, and the control circuit (33, 34, 35) evaluates both outputs of the differential amplifiers(30).

8. (Amended) The circuit as claimed in claim 7, characterized in that wherein the control circuit (33, 34, 35) for supplying current to the coils (14, 16) is ~~designed in such a way that, for transferring the actuator (1) first and second coils transfers the actuator into a final position(19, 20), and~~

the first coil (14, 16) assigned to this the final position (19, 20) firstly carries a capture current (F_s, F_o) and then, after reaching the final position (19, 20), a holding current(H_s, H_o), and in that the control circuit (33, 34, 35) then and a holding current, and the control circuit evaluates the output of the differential amplifier (30) of the other second coil(16, 14).

9. (Amended) The method as claimed in ~~one of claims 1 to 4, characterized in that claim~~
1, wherein the offset error I_o is determined and low-pass-filtered several multiple times.

In the Abstract:

Please replace the Abstract with the substitute Abstract attached hereto.

2025 RELEASE UNDER E.O. 14176

CIRCUIT AND METHOD FOR DETERMINING AN OFFSET ERROR OF A MEASUREMENT SUBJECT TO AN OFFSET ERROR OF A COIL CURRENT OF AN ELECTROMAGNETIC ACTUATOR

Abstract

When measuring the coil current on an electromagnetic actuator, the current through the coil is measured when the actuator is in a final position in which the coil is not supplied with current. An offset error can be determined from the measured value then occurring. In the case of an actuator which drives a gas exchange valve, the offset error determination is preferably performed when the gas exchange valve is in the final position, in which the coil for which the offset error is to be determined is not supplied with current

Description

Circuit and method for determining the offset error of a measurement that is subject to such an offset error 5 of the coil current of an electromagnetic actuator

The invention relates to a circuit and a method for determining the offset error of a measurement that is subject to such an offset error of the coil current of 10 an electromagnetic actuator.

Electromagnetic actuators, which for example drive a gas exchange valve of an internal combustion engine, usually have at least one coil. An electromagnetic 15 actuator for gas exchange valves is known for example from DE 297 12 502 U1 or EP 0 724 067 A1. It has a rest position, which lies between a closed position and an open position and from which it can be deflected by means of electromagnets.

20 To open or close a gas exchange valve driven by this actuator, the coil assigned to the respective final position is supplied with current, the required current being greater in the capture phase than in the holding 25 phase, in which the gas exchange valve is held in the final position of the actuator.

If the corresponding electromagnet is in this case simply provided with current, the valve disk of the gas 30 exchange valve hits the valve seat at high speed, which produces noise and is conducive to wear. To avoid this, the striking speed must be reduced. For this purpose, the current supply is suitably controlled.

35 For this purpose, it is necessary in the case of electromagnetic actuators to measure the coil current. This can take place, for example, by potential taps at a resistor connected in series with the coil. By means

of Ohm's law, the current can be calculated from the value of the resistance and the measured voltage drop.

The voltage drop is usually sensed with an analog circuit. In the case of such an analog circuit, an offset error is unavoidable, i.e. the measured voltage is too great or too small. A measuring device which performs an automatic offset voltage compensation is known from DE 34 29 854 A1, but a special hybrid module is required for it, which is relatively expensive. A similarly acting circuit arrangement is known from DE 34 48 182 C2. In this case, a memory module is used for the offset compensation.

15 The invention is based on the object of providing a circuit of an electromagnetic actuator and a method for determining the offset error of a measurement that is subject to such an offset error of the coil current of an electromagnetic actuator, with the result that no
20 special modules are required.

This object is achieved by the invention characterized in claims 1 and 5.

25 The invention is based on the realization that there is a final position of the actuator in which a coil is not supplied with current. If the coil current is measured at this point in time, the offset error can be determined from this.

30 In the case of an actuator which is used for example for driving a gas exchange valve and in the case of which, for opening or closing the gas exchange valve, the coil assigned to the corresponding final position
35 is firstly supplied with a capture current and then with a holding current, the determination of the offset error is preferably performed on that coil which is assigned to the other final position when the coil

supplied with current is in the holding phase. This is because, at this point in time, it is ensured that the coil of the circuit for which the offset error is being determined is not supplied with current. In the 5 capture phase, this is not ensured, since for example the current from its previous holding phase can still decay or, under certain circumstances, the coil is still briefly supplied with current during the capture phase for the delayed transfer of the actuator into the 10 other final position.

Advantageous refinements of the invention are characterized in the subclaims.

15 An exemplary embodiment of the invention is explained in more detail below with reference to the drawings, in which:

20 figure 1 shows a section through an actuator for a gas exchange valve of an internal combustion engine,

25 figure 2 shows the time series of the current flow through the two coils of figure 1,

figure 3 shows a circuit for sensing the coil current through a coil and

30 figure 4 shows the states passed through during the operation of the gas exchange valve in a flow diagram.

Figure 1 shows an electromagnetic actuator 1 for a gas exchange valve which is designed as a disk valve and 35 comprises a valve disk 2 with a valve seat 3 and a valve stem 4, which is mounted in a guide 5 on the housing side and is provided at the upper end with a conical piece 6. The valve disk is moved by the

actuator 1 between two final positions: in an upper final position, the gas exchange valve is closed and in a lower final position it is open.

5 A valve spring 8 arranged between the guide 5 on the housing side and the conical piece 6 acts on the valve disk, urging it into the closed position.

10 The actuator 1 further comprises an upper ferromagnetic coil former 10 and a lower ferromagnetic coil former 12, which respectively carry a coil 14 and 16.

15 Displaceably mounted within the upper coil former 10 is
an armature shaft 17, which has a plate-shaped armature
18, which lies between the two coils 14, 16. The end
faces 19 and 20 of the two coil formers 10 and 12,
facing the armature 18, form stops for the armature 18
and consequently define the upper and lower final
positions of the gas exchange valve, in which it is
20 open or closed.

An actuator spring 22 is clamped between the armature shaft 17 and a stop 24 on the housing side and acts on the armature 18 in the direction of the open position of the valve disk 2. The armature 18 rests on the valve stem 4. As long as the coils 14 and 16 are not supplied with current, the armature 18 is held by the valve spring 8 and the actuator spring 22 in the midway position between the two end faces 19 and 20, as represented in the drawing.

The two coils 14 and 16 are respectively supplied with current by a driver circuit 26, 27, which are activated by a control circuit 28.

For measuring the travel of the armature disk 2, a piezo element 30' is also provided on the actuator spring support. A further piezo element 32' is

provided on the guide 5 on the housing side. The output signals of the two piezo elements 30', 32' are fed to the control circuit 28, which uses them for the purpose of controlling the striking speed of the armature 6 against the coil formers 10 and 12 on the end faces 19 and 20, respectively, in such a way that the valve can be transferred into the respective final position without bouncing, with little noise, quickly and reliably.

10

In figure 2, the current I through the coil 14 or 16 is plotted over time t. In this case, the current I through the coil 14 is represented by a solid line, the current through the coil 16 is represented by a dashed line. This current flow is set by the control circuit 28, in order with the aid of a capture current circuit to switch the valve over into the other final position, respectively, reliably and without bouncing. For this purpose, the holding current H_s , H_o holding the armature 18 in the respective final position is switched off, so that the armature is set in motion in the direction of the other final position by the relevant, relaxing spring. At the same time, the corresponding winding 14 or 18 is supplied with the capture current F_o , F_s . For closing the valve, the coil 14 is supplied with the capture current F_s . If the armature 18 is resting on the end face 19, the coil 14 is then only supplied with lower holding current H_s , which is sufficient to hold the armature 18, and consequently the gas exchange valve, in the closed position.

For opening the gas exchange valve, the holding current H_s through the coil 14 is switched off and the capture current F_o through the coil is switched on. Once the armature 18 has come up against the end face 20 under the action of the valve spring 8 and the actuator spring 22 and also the magnetic field generated by the

capture current F_o , the supply of current to the coil 16 is switched over to the holding current H_o and the valve disk 2 is held in the open position. To close the valve again, the holding current H_o is analogously 5 switched off and the capture current F_s is switched on.

In other words, the gas exchange valve passes through the states I to IV represented in figure 4. In state 10 I, the valve is closed and the holding current H_s is flowing in the coil 14. Next, in state II, the valve is opened, for which purpose the coil 16 is supplied with the capture current F_o , and the holding current H_s in the coil 14 slowly decays. Once the armature 18 has come up against the end face 20, the supply of current 15 to the coil 16 is switched over to the holding current H_o and the valve is open (state III of figure 4). For closing, the coil 14 is in turn provided with capture current, which is represented in figure 4 as state IV. Once the armature 18 has come up against the end face 20, state I exists again.

In order then to be able to use the current through the coil 14, 16 in the control circuit 28, a measurement of 25 the coil current is necessary. The driver circuit required for this purpose is represented together with a more accurate representation of the control circuit 28 by way of example in figure 3. Figure 3 shows the driver circuit 26 for the coil 14. The driver circuit 27 is designed in an analogous way.

30 As can be seen in figure 3, the coil 14 is activated by an asymmetric half-bridge. In this case, the coil 14 is connected between a highside FET T_h , which on the other hand is connected to the supply voltage V_{cc} , and 35 a lowside FET T_l , which in turn is connected on the other hand via a resistor R to the reference potential. Connected in the forward direction between the reference potential and the connecting nodes of the

coil 14 to the highside FET Th is a diode D2. Connected in the forward direction between the connecting nodes of the coil 14 to the lowside FET Tl and the supply voltage Vcc is a diode D1. Finally, the 5 supply voltage Vcc is connected to the reference potential via a capacitor C. Between the lowside FET Tl and the reference potential there lies a resistor R.

A desired current in the coil 14 is controlled by 10 switching the highside and/or lowside FET Th, Tl on and off. In this case, the actual current is measured by the voltage drop across the resistor R in the lowside branch. The voltage drop is tapped by a differential amplifier 30, the output value of which is fed via an 15 adding node 31 to a filter 33 and on to an analog/digital converter 34 and a microcontroller 35. In the determination of the voltage drop by means of the differential amplifier 30, an offset error is unavoidable, whereby the actual current is falsified.

If the desired current is zero, the highside and lowside FETs Th, Tl are turned off. In this state, no current flows through the resistor R and the voltage at the input of the differential amplifier 30 is zero. On 20 account of the internal construction of the differential amplifier 30, it is possible however for a negative voltage to be present at the output as the result of an offset error. In the case of a measuring chain of a unipolar construction, as usually used in 25 automotive electrical engineering, however, a negative measuring voltage is undesired. For this reason, an artificially generated offset is added on at the adding node 31. For this purpose, the output of a constant-voltage source 32 is additionally fed to the adding 30 node 31. Consequently, there is always a positive voltage present at the input of the filter 33.

For determining the offset error, it must be ensured that the resistor R is not flowed through by a current. This can only be ensured for the coil 14 in the holding phase of the other coil 16, since this concerns a final 5 position in which the coil 14 for the circuit 26 of which the offset error is to be determined is not supplied with current. After determination of the offset error I_o of the non-activated coil, the actual current I_m can be corrected as follows when the coil is 10 next activated in the then-following cycle:

$$I_{corr} = I_m - I_o$$

Preferably, the offset error I_o is measured by being sampled several times in the coil 14 and a weighted 15 average value is formed as follows by using the measured values:

$$I_{o,i} = I_{o,i+1} \cdot (1-k) + I_m \cdot k$$

This weighted average value is one possible form of 20 low-pass filter; others are conceivable. In this case, $I_{o,i}$ is the ith measurement of the offset error, I_m is the actual value of the current(raw value of the analog/digital converter 34) and k is a weighting factor.

25 This low-pass filtering takes account of the realization that the offset error I_o fluctuates in a temperature-dependent manner and changes only slowly with respect to the sampling rate with which the offset 30 error is determined.

The invention was described above in the case of application to an actuator 1 for a gas exchange valve of an internal combustion engine. However, it is not 35 restricted to this, but may also be applied to other actuators. The actuator also does not have to have two coils; it is sufficient for there to be one final position in which a coil is not supplied with current.

Patent claims

1. A method for determining the offset error of a measurement that is subject to such an offset error of the coil current of an electromagnetic actuator (1), in which method
the measurement that is subject to the offset error of the coil current through a coil (14, 16) is performed when the actuator (1) is in a final position in which the coil (14, 16) is not supplied with current during the operation of the actuator (1), and
the value obtained is taken as the offset error.
2. The method as claimed in claim 1, characterized in that the coil current is measured by potential tapping before and after a resistor connected in series with the coil (14, 16), the potential taps being fed to a differential amplifier (30), and a constant value being added to the output value of the differential amplifier (30) in order always to obtain an offset error signal of a specific polarity.
3. The method as claimed in one of the preceding claims, characterized in that, in the case of an actuator (1) with two coils (14, 16) respectively assigned to a final position, the coil current through that coil (14, 16) which is not assigned to the present final position is measured for determining the offset error.
4. The method as claimed in claim 3, characterized in that, for transferring the actuator (1) into a final position, the coil (14, 16) assigned to this final position is firstly supplied with a capture current and then, after reaching the final position, with a holding current, and in that then

the determination of the offset error is carried out on the other coil (14, 16).

5. A circuit for determining the offset error of a measurement that is subject to such an offset error of the coil current I of an electromagnetic actuator (1) having at least one coil (14, 16), with a resistor (R) connected in series into a supply line of the coil (14, 16), a differential amplifier (30), to which the potential on both sides of the resistor (R) is fed, and a control circuit (33, 34, 35), which evaluates the output of the differential amplifier (30) when the coil (14, 16) is not carrying any current during the operation of the actuator (1), and takes the value obtained as the offset error I_o .
6. The circuit as claimed in claim 5, characterized in that the output of the differential amplifier (30) is fed together with the output of a constant-voltage source (32) to an adding element (31), with the result that there is always an offset error signal of a specific polarity.
7. The circuit as claimed in one of the preceding circuit claims, characterized in that, for an actuator with two coils, respectively assigned to a final position (19, 20), a resistor (R) is connected in the supply line to each coil (14, 16), a differential amplifier (30) respectively taps the voltage dropping across said resistor, and the control circuit (33, 34, 35) evaluates both outputs of the differential amplifiers (30).
8. The circuit as claimed in claim 7, characterized in that the control circuit (33, 34, 35) for supplying current to the coils (14, 16) is designed in such a way that, for transferring the actuator (1) into a

final position (19, 20), the coil (14, 16) assigned to this final position (19, 20) firstly carries a capture current (F_s , F_o) and then, after reaching the final position (19, 20), a holding current

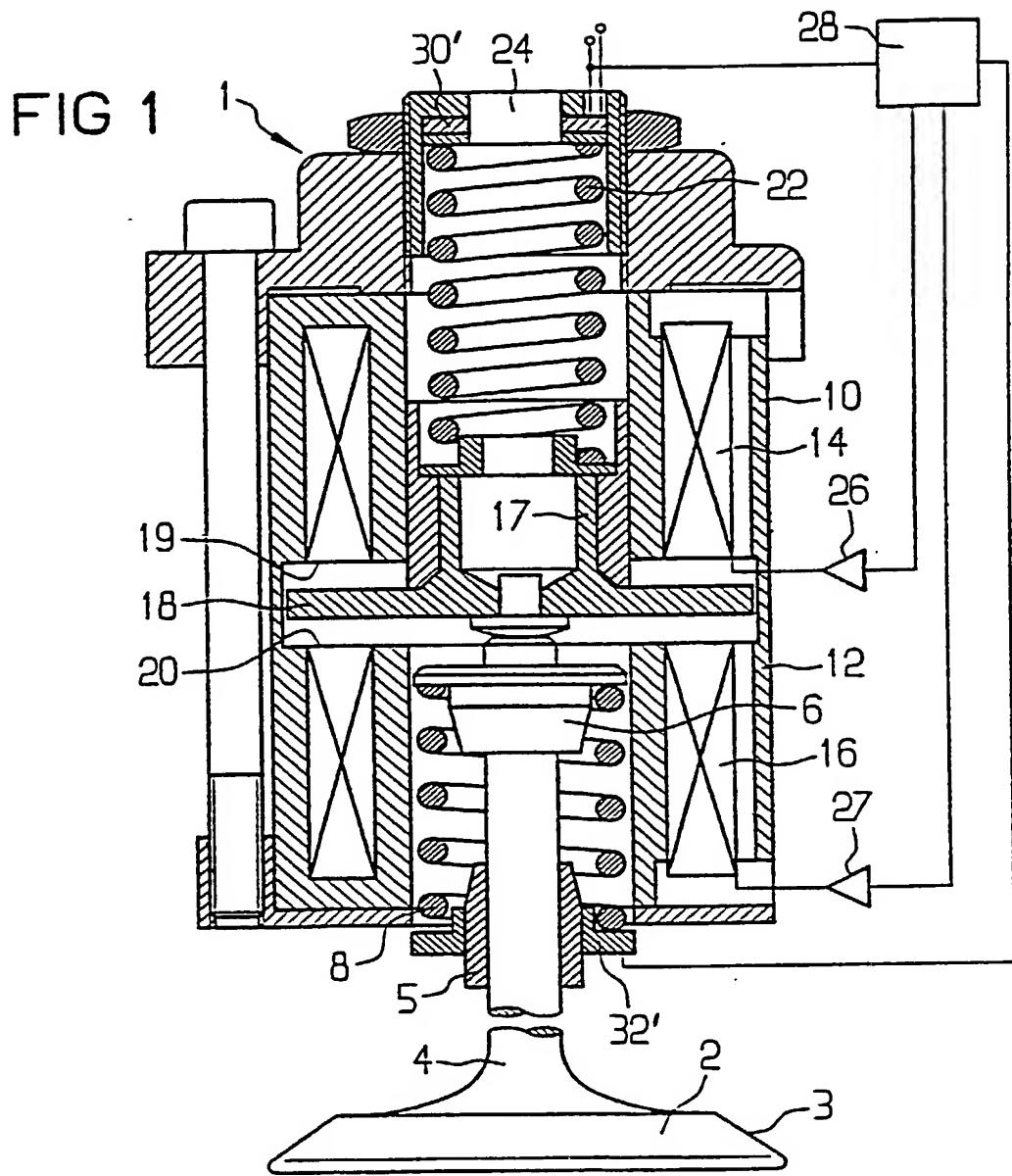
Abstract

Circuit for measuring the coil current of an electromagnetic actuator and method for determining the offset error

When measuring the coil current on an electromagnetic actuator (1), the current (I) through the coil (14, 16) is measured when the actuator (1) is in a final position (19, 20) in which the coil (14, 16) is not supplied with current. An offset error can be determined from the measured value then occurring. In the case of an actuator (1) which drives a gas exchange valve (2, 3, 4), the offset error determination is preferably performed when the gas exchange valve (2, 3, 4) is in the final position (19, 20), in which the coil (16, 14) for which the offset error is to be determined is not supplied with current.

Figure 3

1/4



2/4

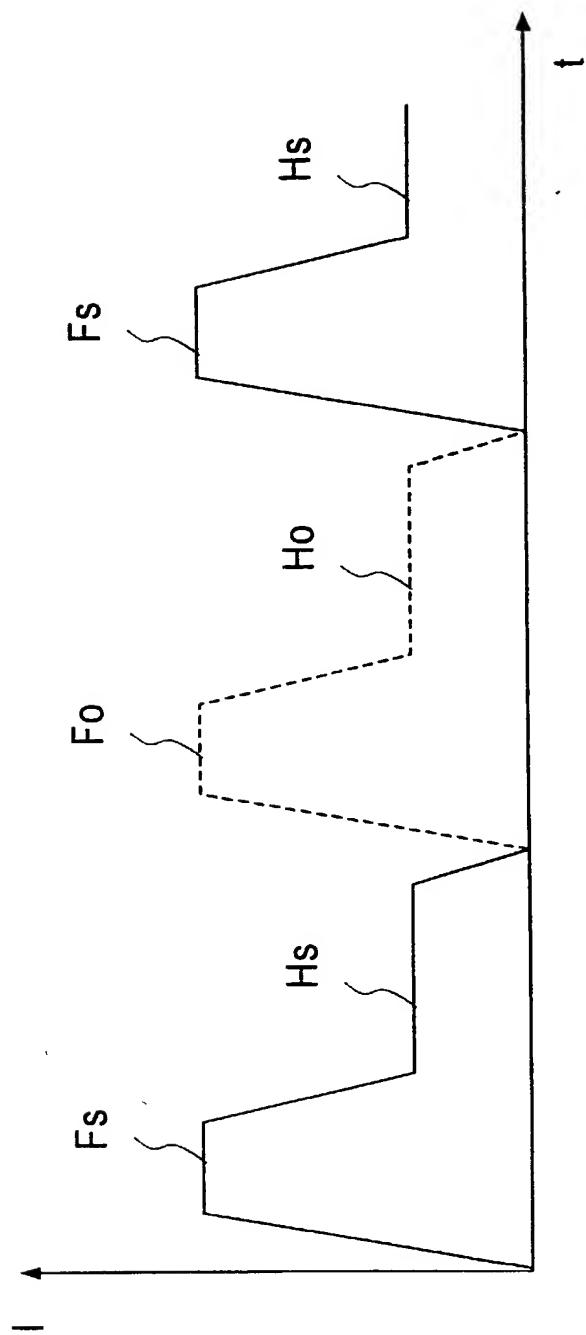
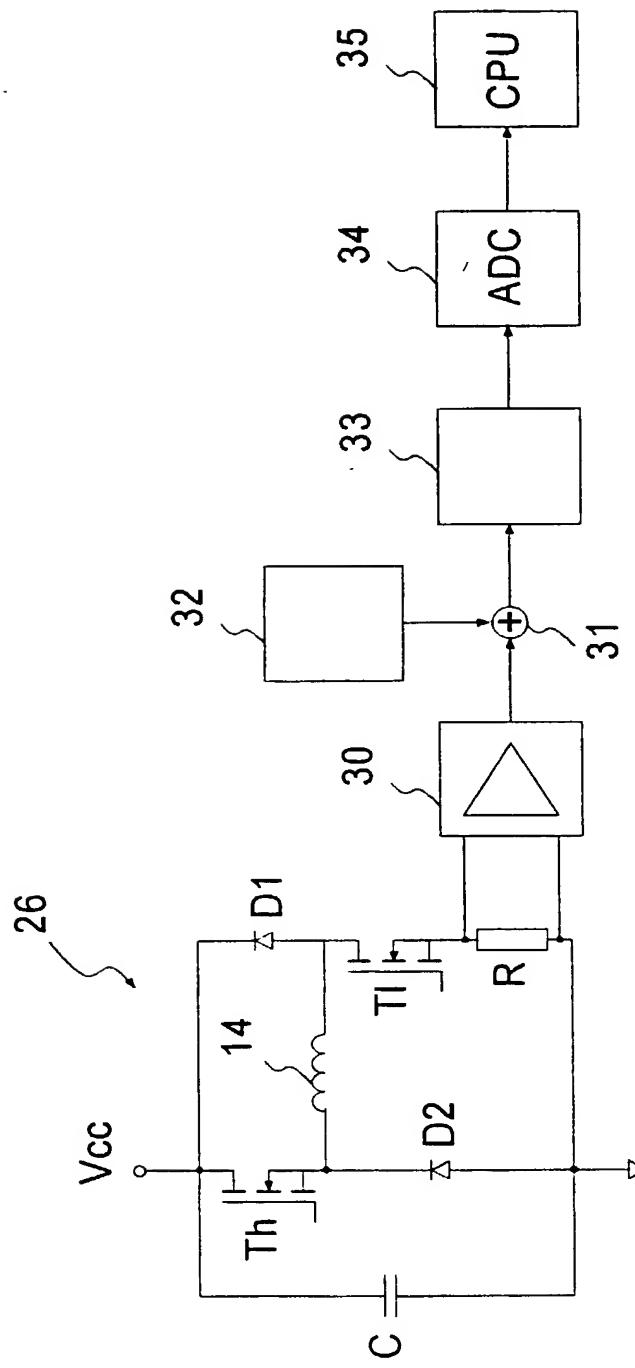


Fig 2

3/4



3
fig

4/4

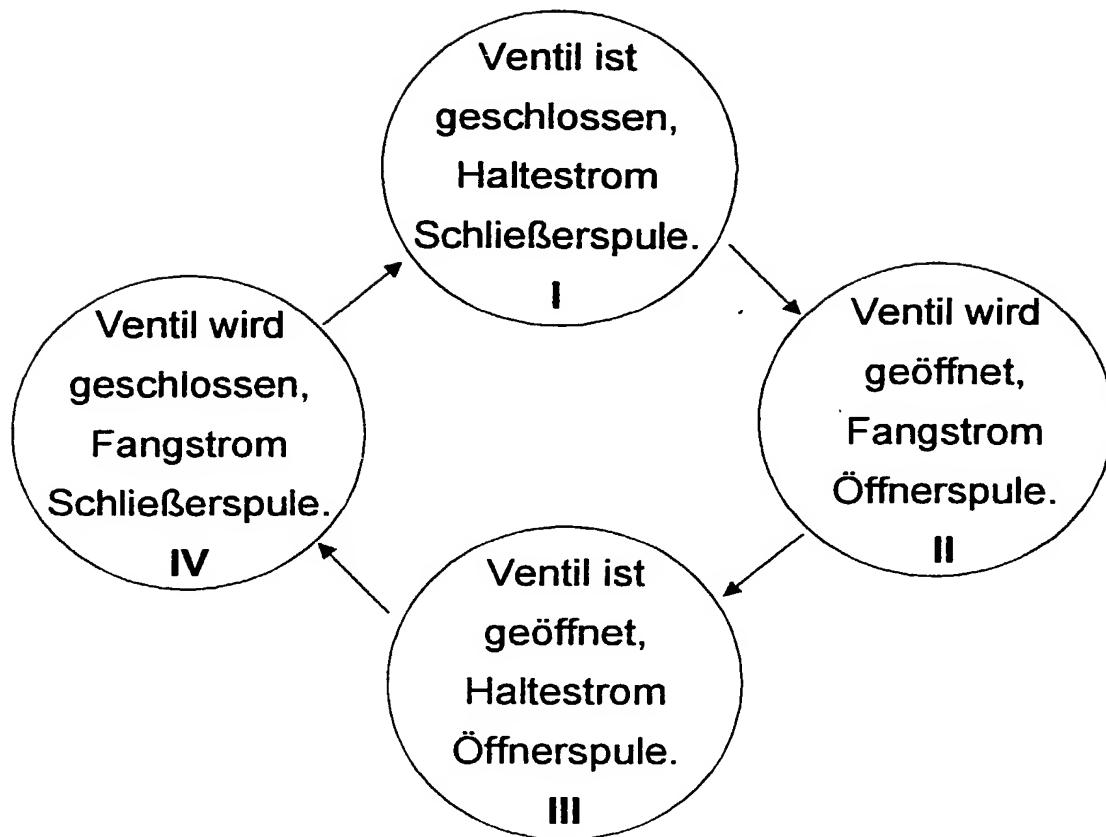


Fig 4

Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
 German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit
an Eides Statt:

dass mein Wohnsitz, meine Postanschrift, und meine
Staatsangehörigkeit den im Nachstehenden nach
meinem Namen aufgeführten Angaben entsprechen,

dass ich, nach bestem Wissen der ursprüngliche, erste
und alleinige Erfinder (falls nachstehend nur ein Name
angegeben ist) oder ein ursprünglicher, erster und
Miterfinder (falls nachstehend mehrere Namen
aufgeführt sind) des Gegenstandes bin, für den dieser
Antrag gestellt wird und für den ein Patent beantragt
wird für die Erfindung mit dem Titel:

**Schaltung und Verfahren zur
Bestimmung des Offsetfehlers bei einer
offsetfehlerbehafteten Messung des
Spulenstroms eines elektromagnetischen
Stellgerätes**

deren Beschreibung

(zutreffendes ankreuzen)

hier beigefügt ist.

am 10.08.2000 als

PCT internationale Anmeldung

PCT Anmeldungsnummer PCT/DE00/02691

eingereicht wurde und am _____
abgeändert wurde (falls tatsächlich abgeändert).

Ich bestätige hiermit, dass ich den Inhalt der obigen
Patentanmeldung einschliesslich der Ansprüche
durchgesehen und verstanden habe, die eventuell
durch einen Zusatzantrag wie oben erwähnt abgeän-
dert wurde.

Ich erkenne meine Pflicht zur Offenbarung irgendwel-
cher Informationen, die für die Prüfung der vorliegen-
den Anmeldung in Einklang mit Absatz 37, Bundes-
gesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind,
an.

Ich beanspruche hiermit ausländische Prioritätsvorteile
gemäß Abschnitt 35 der Zivilprozeßordnung der
Vereinigten Staaten, Paragraph 119 aller unten ange-
gebenen Auslandsanmeldungen für ein Patent oder
eine Erfindersurkunde, und habe auch alle Auslands-
anmeldungen für ein Patent oder eine Erfindersurkunde
die nachstehend gekennzeichnet, die ein Anmelde-
datum haben, das vor dem Anmeldedatum der
Anmeldung liegt, für die Priorität beansprucht wird.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are
as stated below next to my name,

I believe I am the original, first and sole inventor (if only
one name is listed below) or an original, first and joint
inventor (if plural names are listed below) of the
subject matter which is claimed and for which a patent
is sought on the invention entitled

Circuit and method for determining the
offset error of a measurement of the coil
current of an electromagnetic actuator
that is subject to such an offset error

the specification of which

(check one)

is attached hereto.

was filed on 10.08.2000 as

PCT international application

PCT Application No. PCT/DE00/02691

and was amended on _____

(if applicable)

I hereby state that I have reviewed and understand the
contents of the above identified specification, including
the claims as amended by any amendment referred to
above.

I acknowledge the duty to disclose information which is
material to the examination of this application in
accordance with Title 37, Code of Federal Regulations,
§1.56(a).

I hereby claim foreign priority benefits under Title 35,
United States Code, §119 of any foreign application(s)
for patent or inventor's certificate listed below and have
also identified below any foreign application for patent
or inventor's certificate having a filing date before that
of the application on which priority is claimed:

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Prior foreign applications
Priorität beansprucht

Priority Claimed

<u>19938779.6</u> (Number)	<u>DE</u> (Country) (Land)	<u>16.08.1999</u> (Day Month Year Filed) (Tag Monat Jahr eingereicht)	<input checked="" type="checkbox"/> Yes Ja	<input type="checkbox"/> No Nein
 (Number)	 (Country) (Land)	 (Day Month Year Filed) (Tag Monat Jahr eingereicht)	 <input type="checkbox"/> Yes Ja	 <input type="checkbox"/> No Nein
 (Number)	 (Country) (Land)	 (Day Month Year Filed) (Tag Monat Jahr eingereicht)	 <input type="checkbox"/> Yes Ja	 <input type="checkbox"/> No Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

<u>PCT/DE00/02691</u> (Application Serial No.) (Anmeldeseriennummer)	<u>10.08.2000</u> (Filing Date D, M, Y) (Anmeldedatum T, M, J)	<u>anhängig</u> (Status) (patentiert, anhängig, aufgegeben)	<u>pending</u> (Status) (patented, pending, abandoned)
 (Application Serial No.) (Anmeldeseriennummer)	 (Filing Date D,M,Y) (Anmeldedatum T, M; J)	 (Status) (patentiert, anhängig, aufgegeben)	 (Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden können, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent- und Warenzeichenamt: (*Name und Registrationsnummer anführen*)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (*list name and registration number*)

And I hereby appoint

Customer No. 25227

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Staatsangehörigkeit	Citizenship		
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Unterschrift des Erfinders	Datum	Inventor's signature	Date
Wohnsitz	Residence		
Staatsangehörigkeit	Citizenship		
Postanschrift	Post Office Address		

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

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